

# NORTH ATLANTIC TROPICAL CYCLONE ACTIVITY, 1901-1960

G. W. CRY

U.S. Weather Bureau, Washington, D.C.

and

W. H. HAGGARD

National Weather Records Center, U.S. Weather Bureau, Asheville, N.C.

[Manuscript received October 10, 1960; revised April 19, 1962]

## ABSTRACT

Graphical analyses of the observed occurrences of tropical cyclones in the North Atlantic region during the years 1901 through 1960 are presented. Intra-seasonal and inter-seasonal variations of tropical cyclone origins, duration, and intensity are discussed and compared for six geographic development zones. Features of the activity originating in these zones are examined.

## 1. INTRODUCTION

North Atlantic tropical cyclones have been the subject of several climatological studies. Several investigators [1, 2, 3] compiled extensive sets of tropical cyclone paths, and derived information on mean movement, recurvatures, and other features. Colón [4] developed an abundance of useful information for the years 1887 through 1950. Dunn [5] studied the points along the paths of North Atlantic tropical cyclones where hurricane force was probably first attained. This approach was later extended [6] to include the points where the initial circulations leading to tropical storms or hurricanes were first detected.

Dunn and Miller [7] discuss classifications of tropical cyclones. They indicate that groupings according to intensity have been generally accepted by most meteorological organizations, and list a classification with the following categories: (1) tropical disturbance, (2) tropical depression (winds less than 39 m.p.h.), (3) tropical storm (winds 39 to 73 m.p.h.), and (4) hurricane (winds 74 m.p.h. or higher). The relationship between wind speed and storm size is also discussed in relation to another classification, that of the physical characteristics of developing, immature, fully developed, and decaying tropical cyclones.

Cry, Haggard, and White [8] prepared annual and intra-seasonal charts of tracks for all known North Atlantic tropical storms and hurricanes occurring during the years 1886 to 1958, inclusive. For those tropical cyclones after 1899, indications of the intensity along each track were given by categories similar to those above: (1) tropical storm, (2) hurricane, (3) extratropical storm stage, (4) tropical depression (dissipating) stage, and (5) tropical depression (developing) stage. The latter category was included only for storms after 1951.

An important feature which is touched only briefly or is contained implicitly in several of the studies mentioned

above is the seasonal distribution of tropical cyclones developing in the various regions of the ocean. It is our purpose here to examine the features of the seasonal arrangement of tropical cyclone occurrences in a detailed fashion; to investigate the contribution from each of six development zones to the total activity during the years 1901 to 1960; and to discuss the intra-seasonal and inter-seasonal relationships of tropical cyclone frequency, duration, and intensity.

The authors have found that a simple measure of tropical cyclone intensity (the maximum daily wind speed squared) is highly correlated on an annual basis (0.90) with number of days of tropical cyclone activity. While detailed information on intensity would be of considerable value, our discussion is based on the days of activity. The data presented here are made available prior to completion of detailed investigations into monthly and areal correlations of tropical cyclone duration and intensity; it is felt they may be useful in delineating some features of the variations of tropical cyclone genesis and intensity.

## 2. SEASONAL DISTRIBUTION OF TROPICAL CYCLONES

For this study the North Atlantic was divided into six zones. These are shown in figure 1. The zones, while somewhat arbitrary, are geographically logical, and are related to groupings of tropical cyclone origins examined by Haggard [6]. The upper portion of figure 2 is a seasonal summary of the total distribution of tropical storm and hurricane days of all North Atlantic tropical cyclones during 1901 through 1960; hurricane days are indicated by black shading. The lower graphs show the distributions of "beginning dates" and "first attained hurricane intensity dates."

The North Atlantic tropical cyclone season is usually

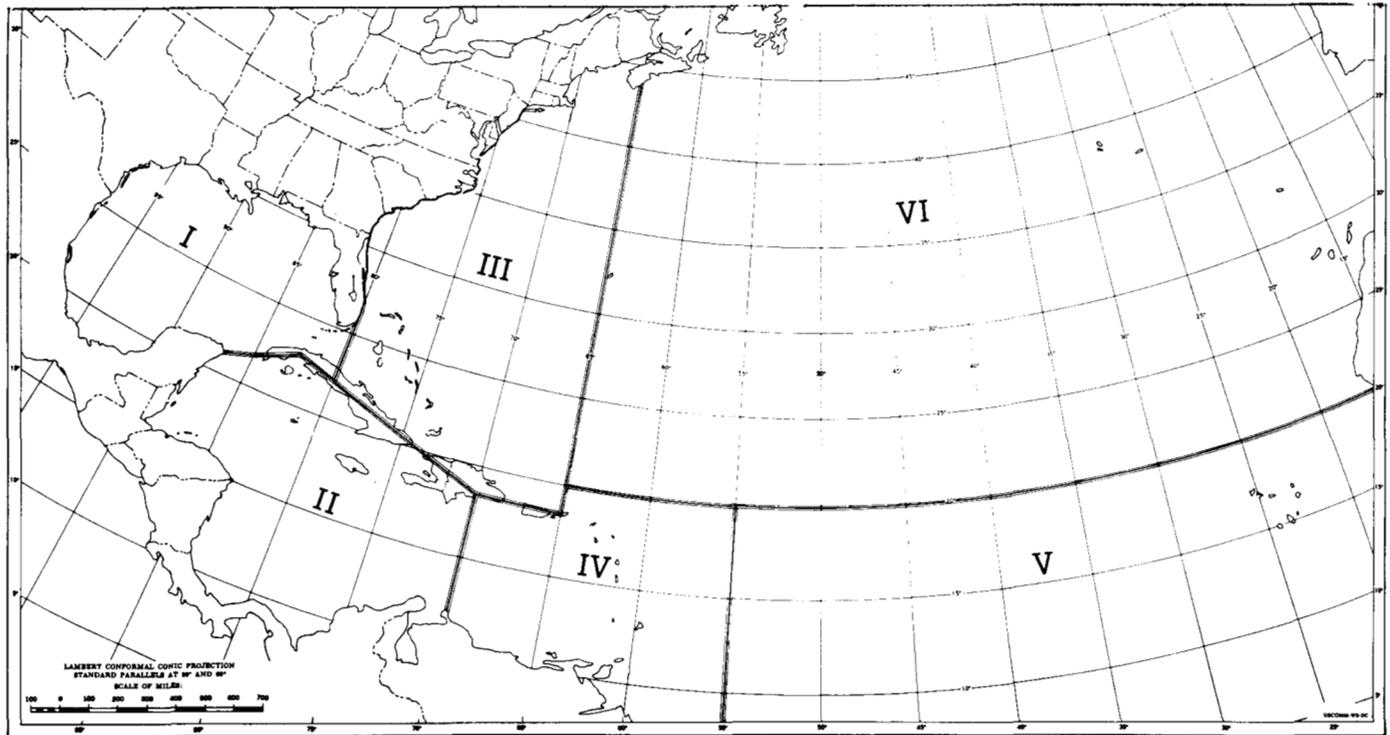


FIGURE 1.—Regional zones in which tropical cyclogenesis in the North Atlantic area is investigated.  
Total Daily Frequency of Tropical Cyclone Occurrences 1901-1960

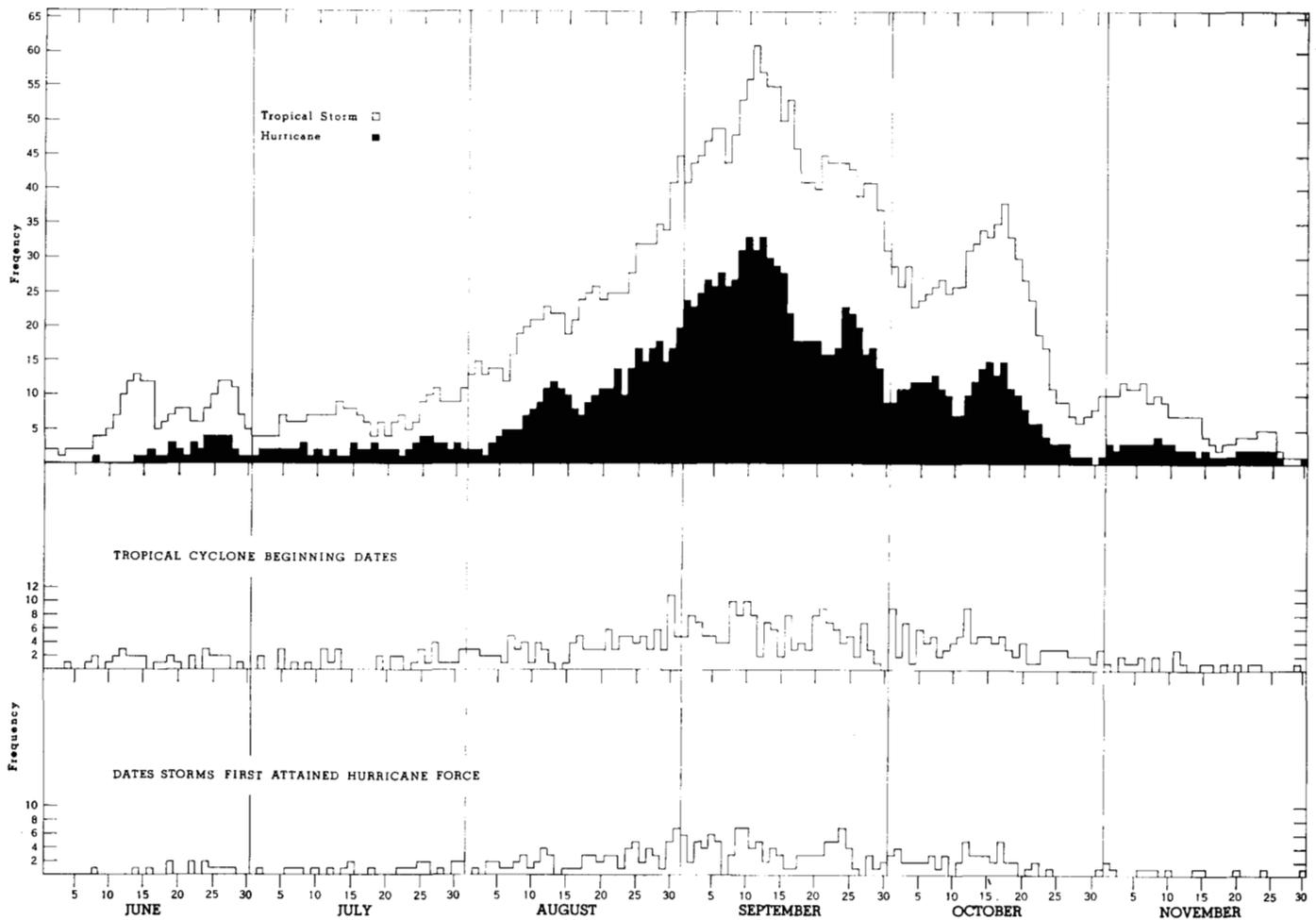


FIGURE 2.—Total daily frequency of tropical cyclone occurrence; tropical cyclone beginning dates; and dates tropical storms first attained hurricane force, 1901-1960.

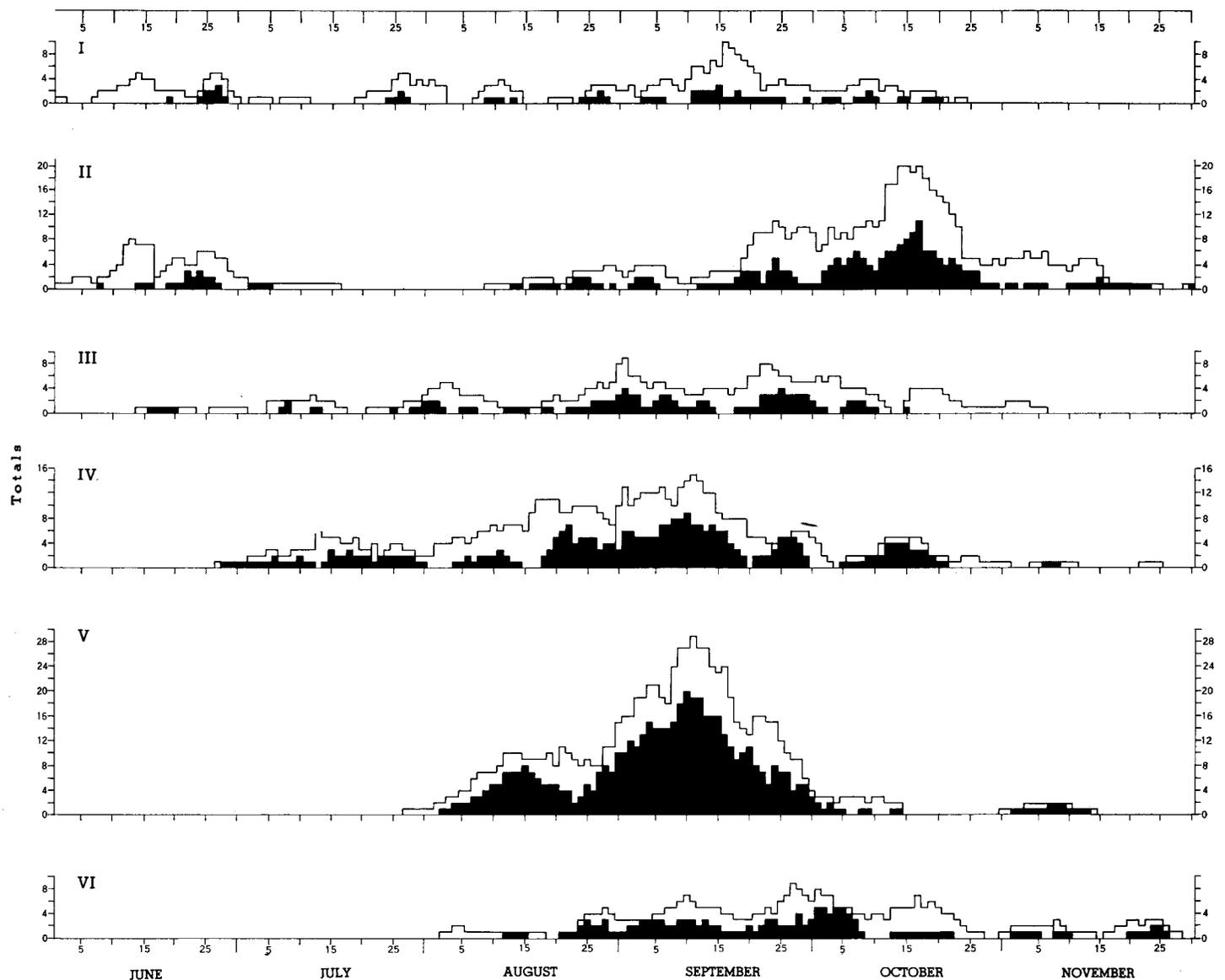


FIGURE 3.—Distributions of tropical storm and hurricane days for tropical cyclones originating in each of the six North Atlantic cyclogenetic zones, 1901-1960.

considered to include the months June through November. Figure 2 shows that June and July may be thought of as prelude and the last part of October and November as postlude to the principal season. An almost unbroken increase to a peak of overall activity occurs during August and the first half of September; the peak is followed by a decline to a briefly-sustained lower plateau, then by a second decrease to a sharply lower level around the first of October. An increase of both tropical storm and hurricane days in mid-October is followed by a sharp decline to a low level of activity in the last part of October and in November.

Figure 3 shows the seasonal distributions of tropical storm and hurricane days for tropical cyclones having origins in each of the six zones outlined on figure 1. On this and following figures, the contribution of each tropical

cyclone is shown only once, this being in the zone where it originated. As an example, a tropical cyclone may originate in Zone V, and follow a path through Zones IV and III into Zone VI before dissipating; it will be shown as a Zone V occurrence only.

Examination of figure 3 indicates that early-season (June-July) activity consists almost entirely of tropical cyclones forming in the extreme southwestern sections of the region. Only three cases in June have been noted outside the Gulf of Mexico and western Caribbean; the favored July genesis regions are the Lesser Antilles and the southwestern Atlantic, with some occurrences in the Gulf mainly near the end of the month.

During August and the first half of September activity is noted in all zones. The principal contributions are from the Lesser Antilles and the southeastern Atlantic as

Zone I Tropical Cyclones Beginning in the Gulf of Mexico 1901-1960

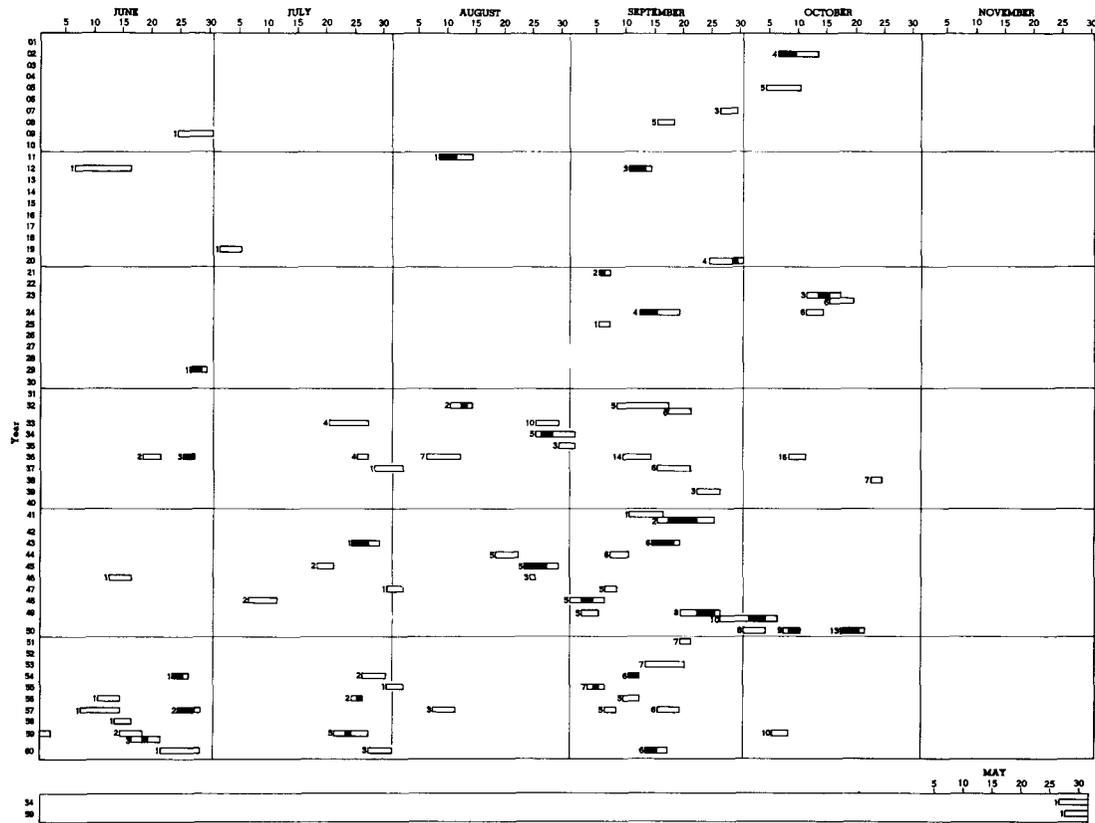


FIGURE 4.—Tropical cyclogenesis in Zone I—the Gulf of Mexico. Open bars represent durations of tropical cyclones which originated in this zone; solid portions represent days of hurricane intensity.

Zone II Tropical Cyclones Beginning in the Western Caribbean west of 70°W 1901-1960

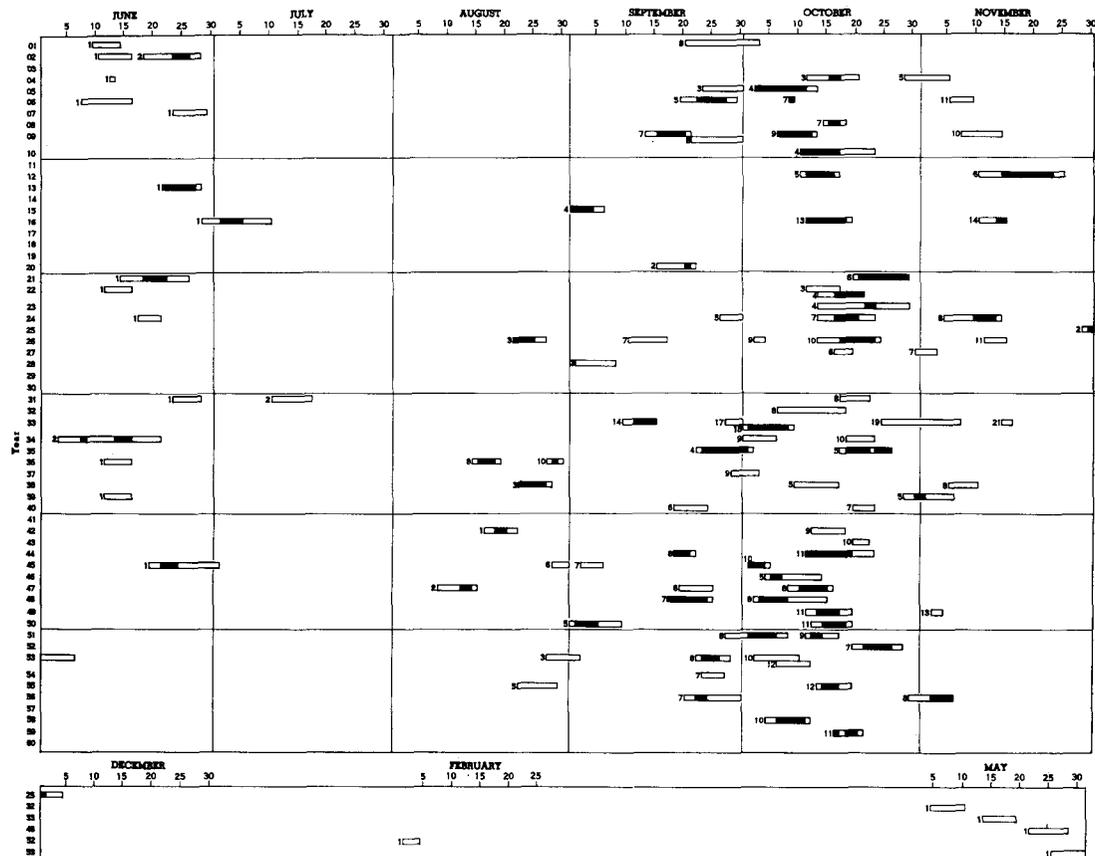


FIGURE 5.—Tropical cyclogenesis in Zone II—the western Caribbean. (Depiction scheme same as figure 4.)

Zone III Tropical Cyclones Beginning in the North Atlantic west of 65°W 1901-1960

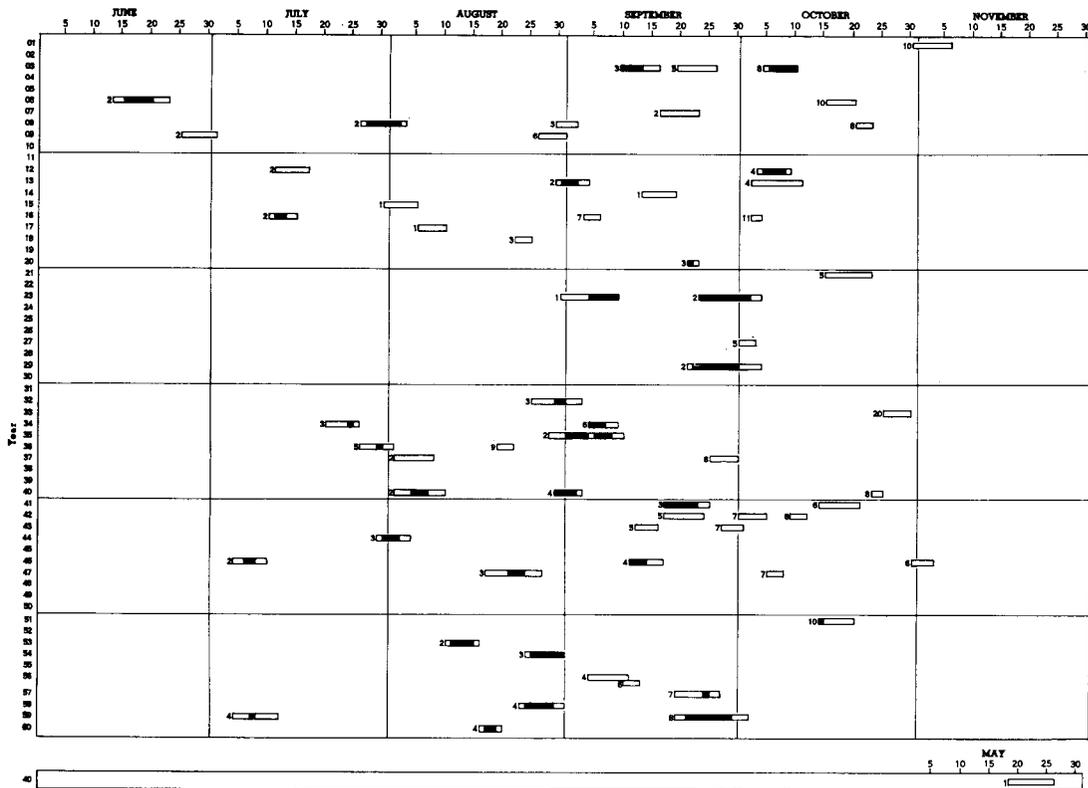


FIGURE 6.—Tropical cyclogenesis in Zone III—the western North Atlantic.

Zone IV Tropical Cyclones Beginning in the Lesser Antilles Region 55°W-70°W south of 20°N 1901-1960

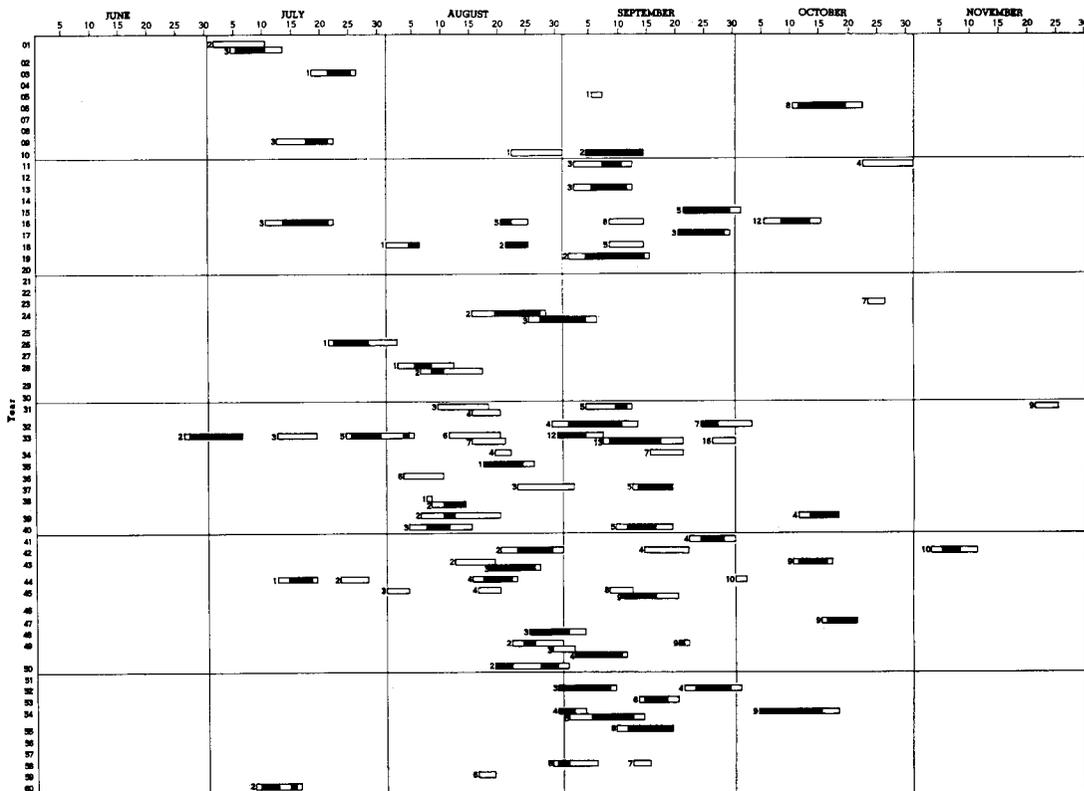


FIGURE 7.—Tropical cyclogenesis in Zone IV—the Lesser Antilles.

Zone V Tropical Cyclones Beginning in the Southeastern Atlantic east of 55°W south of 20°N 1901-1960

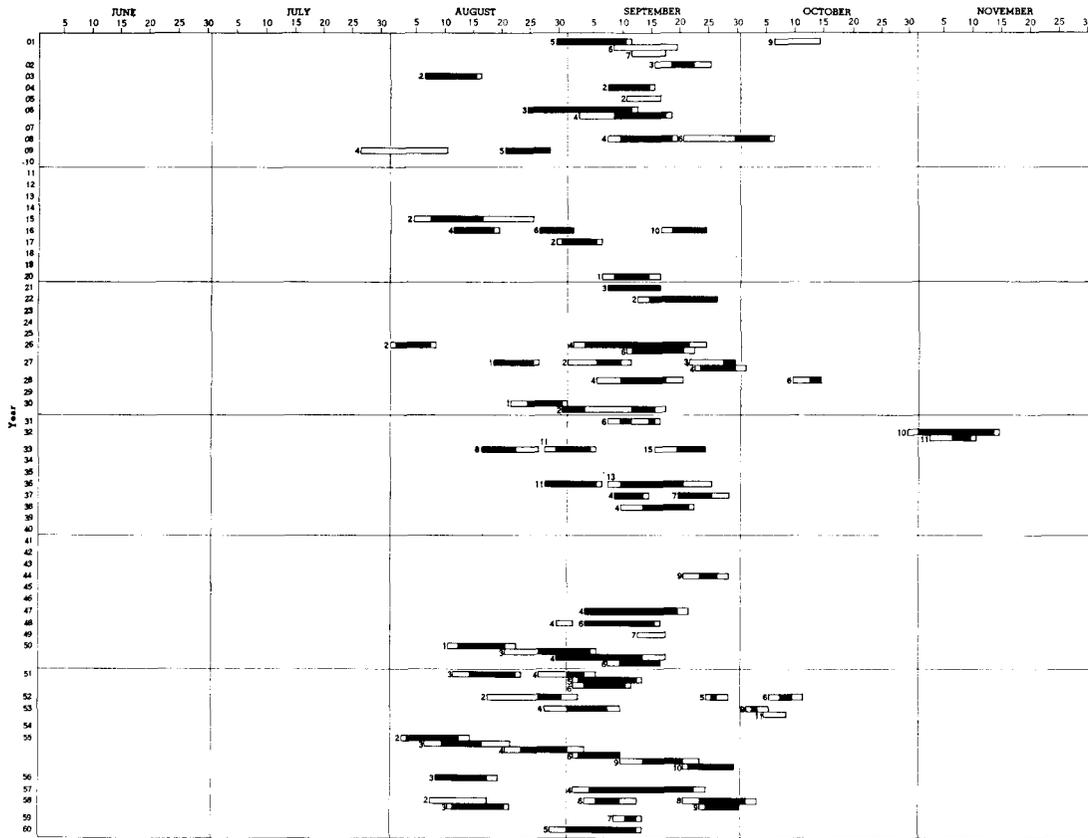


FIGURE 8.—Tropical cyclogenesis in Zone V—the southeastern North Atlantic.

Zone VI Tropical Cyclones Beginning in the North Atlantic east of 65°W north of 20°N 1901-1960

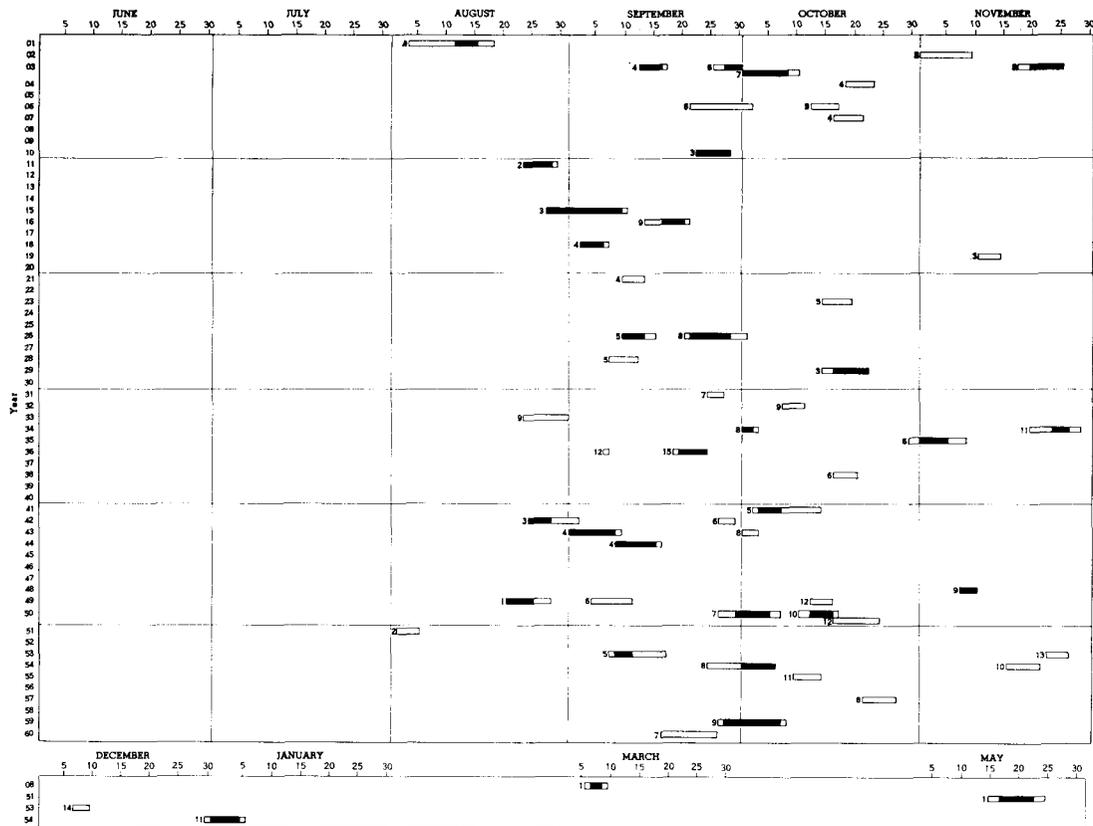


FIGURE 9.—Tropical cyclogenesis in Zone VI—the eastern North Atlantic.

TABLE 1.—Annual frequency of tropical cyclones and hurricanes originating in North Atlantic tropical cyclogenetic zones, 1901–1960. “T” column shows frequency of all tropical cyclones and number of days duration; “H” column shows frequency of hurricanes and number of days of hurricane force duration

Year	Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Total	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H
1901	0	0	2-18	0	1-7	0	2-18	1-5	4-38	1-12	1-15	1-4	10-96	3-21
1902	1-7	1-3	2-16	1-3	0	0	0	0	1-10	1-4	1-9	0	5-42	3-10
1903	0	0	0	0	3-20	2-9	1-9	1-5	1-10	1-9	4-28	4-21	9-67	8-44
1904	0	0	3-18	1-2	0	0	0	0	0	1-7	1-5	0	5-31	2-9
1905	1-6	0	2-18	1-9	0	0	1-2	0	1-6	0	0	0	5-32	1-9
1906	0	0	4-24	2-6	2-15	1-5	1-12	1-8	2-35	2-27	2-16	0	11-102	6-46
1907	1-3	0	1-6	0	1-7	0	0	0	0	0	1-5	0	4-21	0
1908	1-3	0	1-4	1-2	3-15	1-6	0	0	2-28	2-15	1-4	1-2	8-54	5-25
1909	1-6	0	4-31	2-11	2-11	0	1-10	1-4	2-23	1-8	0	0	10-81	4-23
1910	0	0	1-13	1-7	0	0	2-19	1-10	0	0	0	1-6	4-38	3-23
1911	1-6	1-3	0	0	0	0	2-19	1-3	0	0	1-6	1-5	4-31	3-11
1912	2-14	1-3	2-22	2-14	2-12	1-4	0	0	0	0	0	0	6-48	4-21
1913	0	0	1-7	1-6	2-15	1-3	1-10	1-6	0	0	0	0	4-32	3-15
1914	0	0	0	0	1-6	0	0	0	0	0	0	0	1-6	0
1915	0	0	1-8	1-6	1-6	0	1-10	1-8	1-21	1-9	1-14	1-13	5-59	4-36
1916	0	0	3-25	3-13	3-10	1-2	4-33	3-15	3-22	3-19	1-8	1-4	14-98	11-53
1917	0	0	0	0	1-5	0	1-9	1-8	1-8	1-6	0	0	3-22	2-14
1918	0	0	0	0	1-3	0	3-16	2-6	0	0	1-5	1-4	5-24	3-10
1919	1-4	0	0	0	0	0	1-14	1-10	0	0	1-4	0	3-22	1-10
1920	1-6	1-1	1-7	1-1	1-2	1-1	0	0	1-10	1-6	0	0	4-25	4-9
1921	1-2	1-1	2-22	2-13	1-8	0	0	0	1-9	1-9	1-4	0	6-45	4-23
1922	0	0	3-19	1-5	0	0	0	0	1-14	1-12	0	0	4-33	2-17
1923	2-10	1-2	1-16	1-2	2-21	2-14	1-3	0	0	0	1-5	0	7-65	4-18
1924	2-10	1-3	4-28	2-8	0	0	2-25	2-16	0	0	0	0	8-63	5-27
1925	1-2	0	1-6	1-2	0	0	0	0	0	0	0	0	2-8	1-2
1926	0	0	5-30	2-10	0	0	1-12	1-6	3-43	3-33	2-16	2-11	11-101	8-60
1927	0	0	2-7	0	1-3	0	0	0	4-36	4-19	0	0	7-46	4-19
1928	0	0	1-7	0	0	0	2-21	2-5	2-20	2-10	1-5	0	6-53	4-15
1929	1-3	1-2	0	0	1-13	1-8	0	0	0	0	1-8	1-6	3-24	3-16
1930	0	0	0	0	0	0	0	0	2-28	2-14	0	0	2-28	2-14
1931	0	0	3-17	0	0	0	4-22	1-2	1-9	1-3	1-3	0	9-51	2-5
1932	3-17	1-1	2-18	0	1-9	1-2	2-24	2-12	2-24	2-16	1-4	0	11-96	6-31
1933	2-11	0	6-40	2-11	1-5	0	8-70	4-29	3-28	3-17	1-8	0	21-162	9-57
1934	2-12	1-2	3-29	1-4	2-11	2-4	2-9	0	0	0	2-12	2-5	11-73	6-15
1935	1-3	0	2-19	2-15	1-13	1-7	1-9	1-7	0	0	1-10	1-5	6-54	5-34
1936	6-20	2-1	3-13	2-4	2-9	1-1	1-7	0	2-28	2-20	2-7	1-5	16-85	7-32
1937	2-11	0	1-5	0	2-12	0	2-17	1-6	2-15	2-11	0	0	9-60	3-17
1938	1-2	0	3-19	1-5	0	0	2-7	1-4	1-13	1-8	1-4	0	8-45	3-17
1939	1-4	0	2-14	1-2	0	0	2-21	2-7	0	0	0	0	5-39	3-9
1940	0	0	2-10	0	4-24	2-7	2-21	2-9	0	0	0	0	8-55	4-16
1941	2-16	1-5	0	0	2-15	1-6	1-8	1-4	0	0	1-12	1-4	6-51	4-19
1942	0	0	2-12	1-2	3-15	0	3-27	2-9	0	0	2-12	1-4	10-66	4-15
1943	2-10	2-7	1-3	0	2-8	0	3-23	2-13	0	0	2-12	1-8	10-56	5-28
1944	2-7	0	2-16	2-11	1-6	1-3	4-22	2-9	1-8	1-3	1-8	1-7	11-67	7-33
1945	2-9	1-4	4-23	2-6	0	0	4-22	1-6	0	0	0	0	10-54	4-16
1946	2-5	0	1-10	1-2	3-16	2-5	0	0	0	0	0	0	6-31	3-7
1947	2-5	0	3-21	2-7	2-13	1-3	1-6	1-5	1-18	1-16	0	0	9-63	5-31
1948	2-11	1-2	3-28	2-12	0	0	1-10	1-7	2-16	1-12	1-3	1-3	9-68	6-36
1949	3-17	2-3	2-10	1-4	0	0	4-24	3-11	1-5	0	3-19	1-5	13-75	7-23
1950	3-11	2-5	2-16	2-8	0	0	1-13	1-6	4-56	4-39	3-26	2-10	13-122	11-60
1951	1-2	0	2-17	2-7	1-6	1-1	0	0	4-44	4-28	2-14	1-6	10-83	8-42
1952	0	0	2-12	1-5	0	0	2-20	2-15	3-26	3-7	0	0	7-58	6-27
1953	1-7	0	5-38	1-3	1-6	1-4	1-7	1-4	3-21	2-8	3-17	1-3	14-96	6-22
1954	3-9	2-4	1-4	0	1-7	1-6	3-32	3-21	0	0	3-25	2-11	11-77	8-42
1955	2-6	1-1	2-13	1-3	0	0	1-10	1-8	6-72	6-46	1-5	0	12-106	9-58
1956	3-9	1-1	2-18	2-6	2-10	0	0	0	1-11	1-9	0	0	8-48	4-16
1957	5-21	1-3	0	0	1-8	1-1	0	0	1-23	1-18	1-6	0	8-58	3-22
1958	1-3	0	1-8	1-5	1-8	1-5	2-11	1-2	5-50	4-27	0	0	10-80	7-39
1959	5-24	2-2	1-5	1-3	2-21	2-9	1-3	0	1-5	1-2	1-12	1-10	11-70	7-26
1960	3-15	1-2	0	0	1-4	1-2	1-8	1-4	1-16	1-12	1-10	0	7-63	4-20
Total	79-350	28-62	110-790	57-245	65-405	31-118	86-695	57-315	78-857	69-521	57-392	31-162	475-3489	273-1423

the larger, longer, and more intense tropical cyclones spawned in these regions become the predominant type. Activity in these two areas declines after mid-September while that in the other four areas continues later into October. The western Caribbean is the primary genesis zone during most of this month, with activity reaching its peak about mid-month and declining sharply after the 20th. This activity is the primary cause of the October increase in overall activity noted above.

Late-season (second half of October–November) activity is not so closely confined to one region. The principal genesis regions are the western Caribbean, the Lesser Antilles, and the eastern Atlantic north of 20° N. latitude.

### 3. FEATURES OF THE REGIONS OF ORIGIN

Figures 4 through 9 show the dates of occurrence and durations of the individual tropical cyclones which originated in each zone and have been summarized in the preceding section. On these figures the horizontal rectangles delineate the duration of each tropical cyclone; days of hurricane intensity are indicated by black shading. The number beside each rectangle denotes the order of that tropical cyclone in the seasonal frequency for the entire North Atlantic during the particular year.

Table 1 shows the frequency of tropical storms and hurricanes, and the number of tropical storm and hurricane days attributable to each zone during each year.

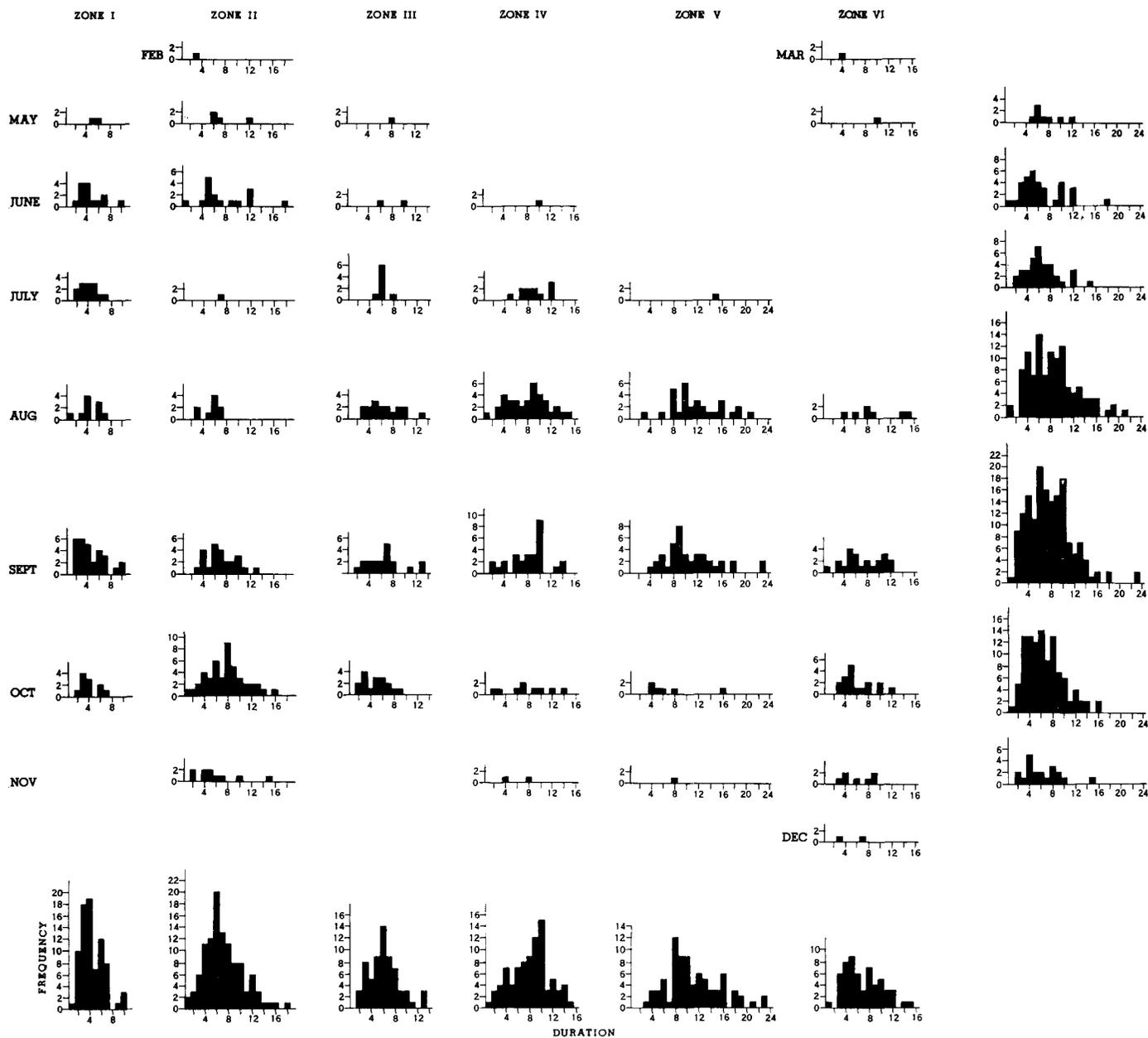


FIGURE 10.—Distributions of tropical cyclone durations by months and zones in the North Atlantic, 1901-1960.

Some outstanding features of tropical cyclone activity in the Gulf of Mexico during the period of this study (fig. 4) are increased frequencies in the last three decades, generally short durations, and a low percentage of hurricanes. Over 78 percent of the cases in this region have occurred since 1932. Only 36 percent of the tropical cyclones developing here have attained hurricane intensity. Some 32 percent of the storms during the last 30 years have reached this force compared to 47 percent during the first 30 years. The average duration of these tropical cyclones is 4.4 days; of hurricane force, 2.2 days. The short durations and the low frequency of hurricanes are influenced by the land-locked character of the region;

tropical cyclones usually pass inland and dissipate within a few days of origin.

Western Caribbean tropical cyclones are shown in figure 5. More tropical cyclones have originated here than in any other zone. The "season" is approximately September 15 to November 15; 63 percent of the 110 tropical cyclones and 70 percent of the 57 hurricanes have begun during these two months. Early season activity—in contrast to the Gulf of Mexico—was more frequent before 1945. No June or July tropical cyclones have been traced to this zone since that year, but two of the four May storms in this zone have occurred since 1948.

The chronology of the tropical cyclones originating in the Lesser Antilles region is shown in figure 7. The season here begins in July, reaches a peak in the first half of September, then declines to near the July level later in September and in October. Two-thirds of the tropical cyclones that originate in this zone attain hurricane force. While August is the month of most frequent origins, September has the greatest total of tropical storm and hurricane days. The years from 1931 to 1950 were the most active period for development in this zone, with 56 percent of the 84 cases beginning during these 20 years. The average duration of storms from this zone is exceeded only by the tropical cyclones developing in the southeastern Atlantic, shown in figure 8.

The seasonal distribution in this latter zone is concentrated almost entirely in August and September. In contrast to the Lesser Antilles, the 1950's have been the period of greatest activity (32 percent of the 60-year total of 78 cases) possibly due to the detection of tropical cyclones farther to the east by aircraft reconnaissance. This region produces the longest-lived and most intense of North Atlantic tropical cyclones. About 88 percent of the storms have reached hurricane intensity; the average duration is 11 days; and the average duration of hurricane force is 7.5 days. Only 16 percent of the total frequency have started here, but these storms have constituted 25 percent of the hurricanes, 24 percent of the tropical cyclone days, and 36 percent of the hurricane days for the entire North Atlantic.

A repetitive pattern of tropical cyclogenesis has been a feature of several zones in various years. This is most notable in the southeastern Atlantic in 1901, 1950, 1951, 1955, and 1958, although the maximum annual frequency for any zone is 8 (Lesser Antilles in 1933) followed by 6 in the Gulf of Mexico in 1936, in the western Caribbean in 1933, and in the southeastern Atlantic in 1955. On the other hand several relatively long periods have been without any activity from the southeastern Atlantic, notably 1910 through 1914 and 1939 through 1943. These 5-year periods have been exceeded only by a 6-year stretch of no activity between 1913 and 1918 in the Gulf of Mexico.

Figures 6 and 9 show tropical cyclone activity originating north of 20° N. latitude. A feature common to both areas is that the year-to-year frequency is rather uniform.

On a decadal basis the maximum for each zone is 13 in the 1930's and 1940's in the western Atlantic and in the 1940's in the eastern zone; the minimum 5, in the 1920's in the western Atlantic and in the 1910's in the eastern Atlantic. The "season" for western origins is mainly late August to early October; it is somewhat later farther east. The only "off-season" storms of hurricane intensity have been spawned in the eastern zone, with one occurrence in the months of December, March, and May.

The durations of tropical cyclones in each zone for each month are given in figure 10. The summary graphs show a relatively sharp peak in the zones and relatively broad monthly maxima. These features emphasize the seasonal "family" similarity of tropical cyclones within the zones and the varying characteristics within the same month of the different zones.

#### ACKNOWLEDGMENT

The authors would like to express their appreciation to the National Hurricane Research Project for support of the work on which this study was based and to Dr. H. E. Landsberg for his interest and guidance. Thanks are also due to Dr. Thomas Gleeson and Mr. H. C. S. Thom for several valuable suggestions.

#### REFERENCES

1. C. L. Mitchell, "West Indian Hurricanes and Other Tropical Disturbances of the North Atlantic Ocean," U.S. Weather Bureau, *Monthly Weather Review Supplement* No. 24, Washington, D.C., 1924, 47 pp.
2. E. B. Garriott, "West Indian Hurricanes," U.S. Weather Bureau, *Bulletin H*, Washington, D.C., 1900, 69 pp.
3. O. L. Fassig, "Hurricanes of the West Indies," U.S. Weather Bureau, *Bulletin X*, Washington, D.C., 1913, 28 pp.
4. J. A. Colón, "A Study of Hurricane Tracks for Forecasting Purposes," *Monthly Weather Review*, vol. 81, No. 3, Mar. 1953, pp. 53-66.
5. G. E. Dunn, "Areas of Hurricane Development," *Monthly Weather Review*, vol. 84, No. 2, Feb. 1956, pp. 47-51.
6. W. H. Haggard, "The Birthplace of North Atlantic Tropical Storms," *Monthly Weather Review*, vol. 86, No. 10, Oct. 1958, pp. 397-404.
7. G. E. Dunn and B. I. Miller, *Atlantic Hurricanes*, Louisiana State University Press, 1960, 326 pp.
8. G. W. Cry, W. H. Haggard and H. S. White, "North Atlantic Tropical Cyclones," U.S. Weather Bureau, *Technical Paper* No. 36, Washington, D.C., 1959, 214 pp.